I am glad you are about enlarging and explaining your principles of natural philosophy. I believe the work will be well received by the learned world.

Benjamin Franklin to Cadwallader Colden.

Philadelphia, Feb. 28th, 1753.

* * * * We are preparing here to make accurate observations on the approaching transit of Mercury over the sun. You will oblige us much by sending the accounts you have received from Lord Macclesfield of his great mural quadrant. I congratulate you on your discovery of a new motion in the earth's axis. You will, I see, render your name immortal.

I believe I have not before told you, that I have provided a subscription here of £1500, to fit out a vessel in search of a north-west passage: she sails in a few days, and is called the Argus, commanded by Mr. Swaine, who was in the last expedition in the Calefornia, author of a journal of that voyage, in two volumes. We think the attempt laudable, whatever may be the success. If he fails, *magnis tamen excidit ausis.*

Mr. Thomas Gilpin laid before the meeting some fine specimens of the Bombax of Santa Cruz.

SPECIAL MEETING.

Eighth Session, 30th May, half past 5 o'clock, P. M.

Dr. Patterson, Vice-President, in the Chair.

Mr. Ellwood Morris made an oral communication relative to the Turbine of Fourneyron, a horizontal hydraulic motor first employed in France in 1827, and of late successfully introduced into use in our country by Merrick & Towne of Philadelphia.

Mr. Morris traced the history of this machine from the first suggestion of Belidor, supported by M. Navier. He adverted to the prize of 6000 francs, offered in 1827, 1829, and 1832, by the Society for encouraging national industry, to the person who should successfully project and put in use two hydraulic motors, which should not waste water, but receive it into their buckets without shock and cause it to leave them without velocity. He alluded to the experimental researches of M. Poncetel and of M. Bardin; the latter of whom employed wheels with vertical axes, and gave them the name of *Turbines*, but without fully complying with the prize conditions. These were attained by M. Fourneyron in 1833, after ten years devotion to the subject, by the construction of two turbines; one of which realized a useful effect of more than 80 per cent. of the power expended, and the other with less expenditure of water than an overshot wheel, which it supplanted as the motive of a blowing machine at a furnace, furnished a greater blast.

Mr. Morris exhibited a full-size horizontal section of a turbine, just constructed by Merrick & Towne for the powder-works of Dupont in Delaware, and a smaller well constructed model, which exposed all the parts of the machine. He explained its theory and mode of action, and made copious references to Fourneyron's Memoir in the Bulletin of the Society for encouraging National Industry for 1834, and to the *Comptes-rendus* of the Academy of Sciences, the Journal of the Franklin Institute, and the works of Morin, for information both as to its theory and the economy of its results.

Mr. Morris next adverted to an apparent error in the conclusions drawn by Fourneyron, from the theory of the turbine, in consequence of his having considered merely a single filament of water, in its progress along a curved guide, and through the wheel, instead of applying his reasoning to the line of motion of the centre of gravity of the issuing particles. M. Fourneyron had thus been led to prescribe a rule for proportioning the tangent angle of the curved guides, which generally gave them at the inner circle of the wheel an inclination of about 45°, with a radius through the same point, instead of an angle of 70°, and upwards, which results from applying the theory to the acting line of the central filament of the moving mass.

In order that the water, agreeably to one branch of the theory, shall act upon the wheel without shock, it is only necessary to cause the final element of the curved bucket recipient of the hydraulic force, to be the resultant of two forces; the one representing the direction and velocity of the centre of gravity of the water issuing from the directing sluices, whilst the other is a tangent to the inner circle of the wheel, and indicates its motion at the point of entrance of the acting fluid.

To cause the water, conformably to the other branch of the theory, to leave the wheel without velocity, the bucket must be curved around sufficiently to receive the full pressure that the head of water is capable of imparting, yet not so much as to obstruct the egress of the fluid when it has done its work; to which end it appears to be necessary, that a tangent to the final element of the curved bucket shall intersect a tangent to the outer circle of the wheel, with an angle opening outwards, of from 10° to 15°.

The curve necessary to satisfy these conditions, has been carefully determined by actual experiment; and Mr. M. remarked, that an advantageous form of the machine having been once devised, it serves as a *type* for constructing others, adapted to a different fall and volume of water. Thus, in the language of M. Combes, a French Engineer of Mines, to whom this generalization is due,—"knowing the fall and the volume of water to be expended, for a "wheel to be constructed, we make it similar to the type; its linear "dimensions will be those of the type, directly as the square roots "of the volumes of water expended, and inversely as the fourth roots "of the heights of fall; its angular velocity will be to that of the "type, directly as the fourth roots of the cubes of the heights of "fall, and inversely as the square roots of the volumes of water expended."

The experiments made in France with the brake of M. Prony have established, that the coefficient of effect of turbines, or the ratio of power actually realized to that expended is at an average seventy per cent. Mr. Morris has recently tested this result at the Rockland Mills in Delaware, where the turbine is employed to drive a cotton mill: his experiments are collated in the table, which closes this abstract.

From these tabulated experiments it will appear, that with lifts of sluice gate ranging from 5 to 7 inches, or from $\frac{5}{8}$ to $\frac{7}{8}$ of the full height of the turbine, and with velocities at the inner circle, varying from about $\frac{4}{10}$ to near $\frac{6}{10}$ of the theoretical velocity, due to the working fall of water, this motor realized an useful effect, varying from 64 to 70 per cent. of the absolute power expended, or of that which is theoretically due to the expenditure of water and the available fall at the time.

The maximum effect seems to have been derived when the lift of the sluice gate equalled 6 inches, or two-thirds of the full height of the wheel; and when the turbine at its inner circle ran at a speed equivalent to 46 per cent. of the theoretical velocity of the water, issuing under a head equal to the working fall.

An examination of the experiments from the 6th to the 14th inclusive, will show that the coefficients of effect within these limits, notwithstanding considerable variations in the relative velocities of the wheel, and its impelling water, averaged 67 per cent.: thus showing that this turbine when run, with a strong lift of sluice gate, realized as high a coefficient of effect as was assigned by Smeaton to overshot water wheels.

With regard to the following table, Mr. M. remarked that the quantity of water used, which fixes the theoretical power due to the expenditure and descent, was determined by applying to the openings of the directing sluices certain coefficients of discharge, deduced from those of Morin on the turbine of Müllbach by a comparison of the velocities and lifts of gate in the one and the other case: the results therefore are merely proximative, but cannot be very distant from the truth.

The total fall of water at the Rockland Mills is usually about seven feet; but the turbine has continued to drive the machinery of the mill effectively when the difference of level was reduced by backwater to three feet three inches, and the wheel was entirely submerged to the depth of four feet. With an external diameter of $4\frac{2}{3}$ feet and a vertical thickness of about 8 inches, it propels the same machinery which heretofore required two breast wheels, one of 14 feet bucket and 10 feet diameter, the other of 8 feet bucket and 16 feet diameter, and uses one-third less water than the latter of these alone.

Mr. Morris next adverted to the durability of the turbine: he supposes it less liable to wear at the pivot than the common water-wheel; as the latter while running supports a heavy load of water, from which the turbine is relieved by the interior fixed disc, which carries the directing sluices. In the turbine at Rockland, the pivot is ingeniously lubricated with oil by a syphon wick passing through an opening in the centre of the vertical shaft; after five months' use, the wear of the pivot is not perceptible.

Mr. M. concluded by exhibiting and describing the original model of an *inverted* turbine, devised by Mr. Young of the Rockland Mills in 1840; and added that a machine, similar in all essential respects, had been contrived by Mr. Erskine Hazard in 1842, without a knowledge of Mr. Young's. Mr. M. mentioned some objections to which he thought the inverted turbines would be liable; and observed, that for the reason he had given while speaking of the durability of the ordinary turbine, he believed that the pressure, and consequently the friction would be the same in all the proposed varieties of the machine and modes of running it.

Experiments upon the Turbine at the Rockland Mills near Wilmington, Del., made by Ellwood Morris, Civil Engineer, January 21st, 1843.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
No. of the Experiments.	Vertical lift of the annular sluice gate in inches.	Aggregate average of the fixed disk openings exposed by the sluice gate in sup. feet.	Proximate coefficients of discharge of the fixed disk openings.	Depression of the water surface in the head and tail races below a fixed level.		Working fall during the experiments.	Theoretical velocity of water due to the working fall in feet per second.	Proximate quantity of water discharged by the Turbine in cubic feet per minute.	Theoretical power in horses' power of 33 000 lbs. lifted one foot high per minute.	Useful effect produced by the Turbine as actually measured by the brake dynamometer of M. De Prony.			Ratio of the speed of the wheel at the inner circle to the theoretical velocity of the water due to the working fall	Approximate coefficient of effect, or ratio of the power actually realized, to the theoretical power.
				In Head race.	In Tail race.					No. of turns of the wheel per minute.	Load of brake at the end of a radius of 11 feet.	Horses' power developed of 33.000 lbs. lifted 1 foot high per min.		
1	1	0.344	.930	3.083	9.937	6.854	20.9	401	5.2	38	14	1.1	.317	.211
2	2	0.687	.923	3.083	9.625	6.542	20.5	779	9.6	58	28	3.4	.500	.354
3	3	1.031	.918	3.125	9.479	6.354	20.2	1146	13.8	72	42	6.3	.621	.456
4	4	1.375	.830	3.188	9.271	6.083	19.8	1355	15.2	74	56	8.6	.652	.566
5	4	1.375								59	70	8.6		
6	5	1.719	.724	3.125	9.187	6.062	19.7	1471	17	57	98	11.7	.505	.688
7	5	1.719	.742	3.125	9.187	6.062	19.7	1507	17.3	67	84	11.8	.593	.682
8	6	2.062	.720	3.229	9.208	5.979	19.6	1745	19.8	64	98	13.1	.565	.662
9	6	2.062	.720	3.229	9.208	5.979	19.6	1745	19.8	59	108	13.3	.525	.672
10	6	2.062	.700	3.188	9.125	5.937	19.5	1688	19	46	136	13.1	.411	.690
11	6	2.062	.700	3.188	9.125	5.937	19.5	1688	19	52	122	13.3	.465	.700
12	7	2.406	.700	3.125	9.042	5.917	19.4	1960	22	49½	136	14.1	.445	.641
13	7	2.406	.700	3.104	8.958	5.854	19.3	1950	21.6	56½	122	14.4	.510	.667
14	7	2.406	.700	3.146	8.958	5.812	19.3	1950	21.1	60	115	14.4	.542	.683

Dr. Meigs made some remarks upon Cyanosis Neonatorum, and upon a new and more successful mode of cure.

To illustrate these, he exhibited a magnified model of the fœtal heart; in which were shown the auricular cavities, with their septum; the foramen ovale covered, on the left side, with its valve; the Eustachian valve, and the passages to the ventricles, with the great vessels, &c.

Dr. Meigs remarked, that the representation showed the Eustachian valve, springing from the anterior column of the arch of the foramen ovale, and extending to the anterior limb of the circular orifice of the inferior cava, and demonstrated the truth of Winslow's rationale of the fœtal circulation, viz:—that the blood of the inferior cava passes mainly across the auricle, and raising the valve upon the left side of the septum, enters the left auricle, passing thence to the left ventricle and the systemic distribution, without reaching the pulmonary branches. The model showed further, that the blood of the upper cava falls into the auricle opposite to the iter ad ventriculum, passes most readily through that opening, and that there is therefore a crossing of the currents.

It is not rare to meet with new born children, especially with those that are premature, in whom this crossing of the currents continues after birth. Any considerable degree of this decussation, Dr. Meigs remarked, involves of necessity the production of the state called *cyanosis*,—a state in which the entire mass of blood becomes loaded carbon. Asphyxia, more or less complete, is the consequence of the failure to eliminate the carbon and to absorb the oxygen. This asphyxia is Cyanosis, or Morbus Cœruleus.

Dr. Meigs had seen a great many patients die under these circumstances. The books contained no rationale for a philosophical treatment, and he was much at a loss to discover a successful one. He found upon reflection, that the valve of the foramen ovale is lifted by the current from the inferior cava, projected against it by the sides of the Eustachian valve, and also by the gravitation of the blood in the right auricle if the child be lying upon its left side. These reflections he made, while in presence of an infant apparently in the agonies of death from cyanosis. He laid it on its right side, with its head and shoulders inclined upwards on pillows, and requested that it should remain for several hours in that position. The success of this mechanical treatment was perfect.

Upon placing the child thus, its septum auricularum became a horizontal plane, supporting the blood in the left auricle. The weight of that blood pressed the valve of the foramen ovale into coincidence with the plane of the septum, and closed the patulous orifice. The succeeding injections of blood took their proper route to the lungs and the system; so that a few acts of the respiratory muscles gave sufficient doses of oxygen to the blood to diminish and rapidly to remove the excess of carbon; and the child was cured. This treatment, Dr. Meigs stated, had been successful under his administration of it, in rescuing from impending death upwards of twenty persons. It begins, he said, to be understood and practised extensively in Philadelphia, and other parts of the United States. But he was desirous to take advantage of the present convention of the Philosophical Society, at which so many members of the profession were present, to exhibit his model, and to make these explanations of a mechanical treatment of a before unmanageable and fatal disorder.

Prof. Bache gave an account of the observations made at Philadelphia and Toronto, during the magnetic disturbance of May 6, 1843, and pointed out their bearing upon the question of the kind of instruments and observations appropriate to determine the phenomena during rapid changes of the magnetic elements.

The disturbance was first noticed at Philadelphia between 3 and 4 P.M. (9 and 10 P.M. Göttingen time), when observations at term-day intervals were commenced. At 12 hours, Göttingen time, observations were begun upon the declinometer at every two minutes (the mean time corresponding to the even minutes), and upon the horizontal force magnetometer at alternate intervals of two and four minutes, and generally at 0, 4, 6, 10, &c. minutes after each hour. The vertical force magnetometer was observed every six minutes, viz. at 2, 8, 14, 20, &c. minutes after the hour, throughout the disturbance. The instruments were most disturbed between 9½ P.M. of the 5th, and 1 A.M. of the 6th of May, Göttingen time, and again between 4½ and 8 A.M. Göttingen time. From about 2 A.M. to 6 A.M., and again from about 7 until 8 A.M. Göttingen time, observations were made upon a small horizontal force magnetometer, and upon a Lloyd inclinometer placed in a building not far from the Observatory. The extremes of vibration in each were noted, so that the mean time of the several observations of the horizontal force instrument corresponded to 0, 2, 6, 8, 12, &c. minutes from the time of beginning, and of the vertical force to 4, 10, 16, &c. minutes.

A similar disturbance was perceived at Toronto, Canada; where the instruments were observed at the term-day intervals from about 10 P.M. Göttingen time, of the 5th of May, until midnight at Toronto. The declination magnetometer was thus recorded at 0, 5, 10, 15, 20, &c. minutes after each hour, the horizontal force magnetometer at 2, 7, 12, 17, &c. minutes, and the vertical force at 3, 8, 13, 18, &c. minutes after each hour. Prof. Bache owed to the kindness of Lieutenant Younghusband, R. A., director of the observatory at Toronto, and to the liberal character of the instructions for the government of the British observatories, the communication of the observations made at Toronto, and the permission to use them.

Prof. Bache had hoped that similar results might have been obtained from the magnetic observatories at Cambridge and Washington, but no special observations had been made there. He regretted to learn from Professor Peirce that the observations at Cambridge had, in fact, been discontinued.

The instruments in the Observatory at the Girard College are of the largest dimensions in use, the declinometer and the bifilar being of Gauss's pattern, and the vertical force magnetometer upon a corresponding scale. The time of vibration of the instruments respectively is 24, 45, and 30 seconds. The Toronto instruments are of the comparatively moderate dimensions of Professor Lloyd's pattern. The subsidiary horizontal force instrument at the Girard College is of still smaller dimensions, being 9¾ inches long; its time of vibration is about ten seconds. It was to the comparative results obtained with these instruments of different dimensions and very different times of vibration, that Prof. Bache wished particularly to direct attention. In a letter received from Col. Sabine, dated May 1st, 1843 (extracts from which Prof. Bache read), a resumé is given of the opinions of the leading magneticians of Europe upon this question, showing that contributions towards its determination are required. This letter contains, further, a discussion of the appropriate intervals of observation, in reference to which the comparative results now presented showed that the intervals at present used are probably incompetent to give an accurate representation of the phenomena.

The following comparisons were illustrated by referring to the broken lines, traced in the usual manner for representing the changes in the different instruments.

Declination.—During a small portion of the first part of the disturbance, when the Philadelphia observations were made at intervals of six minutes, and those at Toronto at intervals of five, it was difficult to judge how far the apparent discrepancies in the movements of the magnets were real, though some of them were probably so. When the observations at Philadelphia at intervals of two minutes began, it was at once apparent that the rapid movements were dissimilar. Commencing the comparison at 24 hours (12 P.M.) Göttingen time, the needle appeared to move, at Philadelphia, steadily eastward from 24 hours to 24 hours 6 minutes; while at Toronto, at 24 hours 05 minutes it appeared to be to the west of its position at 24 hours. At 0 hours (May 6, 24 hours May 5) 16 minutes, a very small minimum occurred at Philadelphia, between two maxima at 0 hours 14 minutes and 0 hours 18 minutes; while at Toronto, at 0 hours 15 minutes, there was a very low minimum. At 0 hours 25 minutes there was a maximum, and at 0 hours 30 minutes a minimum, at Toronto, neither of which appeared at Philadelphia. During this part of the disturbance the changes of declination appear to have been very rapid, and the apparent coincidences of phenomena at the two places are not satisfactory. The intervals between the observations were obviously too great to represent the phenomena accurately. Were the phenomena really dissimilar? or will the difference in the dimensions of the instruments explain the discrepancies?

During the second great movement in this disturbance, which began about 3 hours 50 minutes, A.M., of May 6th, Göttingen time, the motion of the needle was less rapid than during the first, and the results at Philadelphia and Toronto agree better, though between 5 hours 40 minutes and 5 hours 58 minutes, they are quite discrepant. Excluding this period, there were seven apparent maxima out of fourteen, the times of which agreed precisely with those at Toronto; one only of these not being very clearly defined. Five others were within two minutes, the differences of time being fairly referrible to differences in the epochs of observation. One was without a corresponding maximum at Toronto, the discrepancy arising probably from the same cause; only one was a real discrepancy. The correspondence in the times of occurrence of minima of declination was as close as that of the maxima. The extent of the corresponding movements in the two places was, however, by no means proportionate in different cases. It would appear from these results, that when the changes in the declination were not rapid, the large bar gave the same epochs and directions of change as the smaller one, which renders it probable that the discrepancies observed in more rapid changes were due to the difference of instruments rather than to real differences of phenomena. This, however, Professor Bache remarked, is a point which further observation would more satisfactorily determine.

Horizontal force. The curves representing the period of the first considerable change of horizontal force at Philadelphia and Toronto, presented striking discrepancies, with one remarkable coincidence, that of the greatest movement of increase. The maximum was reached at 23 hours 44 minutes, Göttingen time, at Philadelphia, and 23 hours 47 minutes, at Toronto, these being the nearest corresponding periods of observation. Between 23 hours 22 minutes and 23 hours 44 minutes, there was an apparent increase of horizontal force at Philadelphia, of .017 (428 divisions of the scale of the instrument), and at Toronto of .027 (306 divisions of the scale).

It was during the second period of disturbance that the small bifilar instrument was observed at Philadelphia as well as the large one. Taking the periods of maxima and minima as shown by the broken lines it appeared, that when the results given by the Gauss instrument at Philadelphia were compared with those of the Toronto instrument, in twenty-six cases, ten agreed, six were doubtful, and ten disagreed. When the corresponding epochs, as shown by the small horizontal force instrument at Philadelphia and the Toronto magnetometer, were compared in seventeen cases, thirteen agreed, two were doubtful, and two disagreed. The range of movement of the small bifilar was but about one-sixth that of the large one, and in general the means of accuracy of observing inferior; and yet the coincidence of its results with an instrument approaching to its dimensions is very striking. The strongest feature in this part of the disturbance was a decrease of force between 5 hours Göttingen time, and 5 hours 55 minutes. The Gauss bifilar at Philadelphia gave the amount of change .015 of the horizontal force, the small bifilar gave .034 and the Toronto instrument .025. In three corresponding changes of smaller amount, the three instruments taken in the order just named gave respectively for the first change .0039, .0099, .0085; for the second change, .0012, .0025, .0057; for the third change, .0016, .0036, .0036.

Vertical force.—The results of a comparison of the movements of the vertical force instruments at Toronto and Philadelphia were shown to confirm those deduced from the comparison of the bifilars, though it was remarked that the inference is less unexceptionable than in the former case, because the amount of friction at the axes of the two instruments is very different.

Professor Bache stated, in conclusion, that it was his intention to pursue this subject, by mounting a set of small magnetometers to be observed during disturbances, and by observing the Gauss bifilar and perhaps the declinometer, at each vibration, on the same occasions, whenever it might be practicable.

Dr. Goddard called the attention of the Society to the experiments of Moser, which had been supposed to prove the existence of invisible photographic rays.

He said, that in repeating these experiments with much care, he had entirely failed to obtain an image. This failure he ascribed to the fact, that before attempting the supposed photographic process, he had made the cameo or coin which was to produce the image, and the plate on which it was to be received, *perfectly clean*. On mentioning the circumstance to Mr. Joseph Saxton, of the U. S. Mint, whose expertness in experimenting is well known to the members of the Society, he learnt that numerous and careful trials had proved to his satisfaction, that the effect remarked by Moser was due to the evaporation of some greasy substance from the surface of the object forming the image, and that when this had been first carefully removed, no image was obtained. This had recalled to Dr. G.'s mind an observation which he made some years ago, while prosecuting a series of experiments on the Daguerreotype. He had wrapped some highly polished plates in a very old newspaper for the night, and found in the morning that the outer plates had received a perfectly distinct image of the printing that had been in contact with them. Thinking that this was owing to the contact, he enclosed some similar plates in very fine and clean tissue paper, and wrapped the newspaper over this; but the impression appeared in the morning as before, the oil having traversed the tissue paper. This led him to the precaution of employing tin boxes to keep the plates when made ready for the Daguerreotype process.

Dr. G. concluded by expressing his entire concurrence in the opinion of Mr. Saxton, that the effects observed by Moser were due to the evaporation of oily or other organic substances which had accumulated on the surface of the body forming the image, and that the agency of heat was important only as it facilitated the evaporation. He added, as his belief, that all substances evaporated at all times and under all temperatures; the only difference being in the rate: in one case it was inappreciable from its slowness, in another distinguished readily by the phenomena which it produced.

In the course of his remarks, he alluded to the first employment of bromine in the photographic process, and exhibited the first Daguerreotype specimen produced by means of it. It was made in Philadelphia, by himself and Mr. Cornelius, in December, 1839.

The remarks of Dr. Goddard led to a free conversation on the subject, in which Mr. Saxton, Professor Henry, Professor James Rogers, and other gentlemen, took part. In the course of it, the following account was given of Mr. Saxton's experiments.

A gold coin, half an eagle, which had been dipped in pure nitric acid, then washed in distilled water, and afterwards dried by whirling in the air, was placed on a well prepared Daguerreotype plate, and suffered to remain undisturbed for four days. At the end of this time no impression was visible when the plate was breathed on, except at two spots corresponding to the opposite sides of the coin where it had been grasped by the wooden pincers when plunged into the acid.

A copper coin was next placed above a Daguerreotype plate, with nothing between them but an exceedingly thin plate of mica, which had been split from the middle of a thick piece. But after so remaining for three days, no impression of the coin could be observed, though the mica was found, by actual measurement, to be less than the one-thousandth of an inch in thickness. The same coin, placed on the same plate, without the interposed mica, gave an impression in the course of four hours; and when the coin was slightly warmed, a like effect was produced in one hour.

To determine if there was any difference in the screening effect of different substances, a thin plate of sulphate of lime was next placed between the coin and the prepared plate, and the whole suffered to remain five days: at the end of this time, however, no image could be perceived.

In another experiment, a thin plate of glass was interposed between the coin and the plate, with the same negative result. The experiments were also varied by using different metals; but in no case were any effects produced through the thinnest transparent substance which could be procured.

That this was not due to the distance of the coin from the plate, was evident from the fact, that when the former was supported, by pieces of mica under its edges, at the same distance as in the last experiment, an image of the part of the coin not screened by the mica was impressed on the plate, while no such effect was produced by the parts under which the mica was placed.

As, then, those parts of the coin which are either perfectly clean or which have been thus screened give no image, the conclusion is, that the effects observed by Moser are due to the evaporation of the volatile matter which has infilmed the coin. Some parts of the coin, such as the salient points of the figures, would be differently soiled from the others, and would also evaporate the volatile or fatty matter differently; and when the coin is placed very near a polished surface, the condensation of the evaporated matter on this surface would be different at different points, and present the appearance of an image.

The principle of the formation of these images may be simply illustrated by slightly touching the point of the finger to a clean plate of glass. If the plate be afterwards breathed on, the vapour will be differently condensed on the parts which have been in contact with the raised lines of the skin; and hence an image of the surface of the finger will be exhibited on the glass. If the finger could be held at the distance of the one-fiftieth of an inch for a few hours, the same effect would be produced by the unequal vaporization.

The same conclusion has also been arrived at by M. Fizeau, and was communicated to M. Arago in November last; but the investigations of Mr. Saxton were entirely independent of any knowledge of the French experiments, and his explanation of the phenomenon had been communicated to Professor Henry and other members of the Society, before any account of the experiments of M. Fizeau reached this country.

Professor Rogers also mentioned, that he had repeated some of the experiments of Mr. Saxton at the time, and had been fully convinced that his explanation of the images was the true one.

Prof. H. D. Rogers made an oral communication, under the title of "Geological Notices."

He alluded first to the subject of Coprolites, which had been brought before the Society by Mr. Lea, and stated that he considered the specimens, which he had discovered in the green sand formation of New Jersey, to belong to the fossil Crocodile, with whose bones he found them. He did not know whether those previously collected by Dr. De Kay appertained to the same animal; but thought it probable they did.

He then passed to the subject of the paper read by Mr. Taylor, the flora of the carboniferous period. The generalization first fully announced by Logan, that each seam of coal reposes on a peculiar indurated mud, called fire-clay, in which abounds a characteristic plant, the *Stigmaria ficoides*, has been of late extensively confirmed by observations in this country, made by Logan, Lyell, and some of our home geologists. Prof. R. read a letter from Mr. Weld to Prof. Ducatel, which goes to show, that in one or two cases of apparent exception to the rule, in the Potomac coal-field, a critical reëxamination of the strata has resulted in the detection of the fire-clay and its plants, in close contact with the under side of the coal. Prof. Rogers thinks that each bed of coal is an ancient stigmaria bog; slow decomposition by moisture, and exclusion of air, having caused the conversion to coal.

He then proceeded to apply the doctrine of earthquakes, contained in the paper by his brother and himself, to the explanation of certain geological phenomena in the Appalachian chain of the United States. He showed by reference to a general section and several pictorial views, that each anticlinal flexure of this mountain region exhibits, with few exceptions, a more rapid arching on its N. W. side, or the side remotest from the region of greatest subterranean disturbance; and that as we recede to the N. W., the plication of the strata lessens, the curves flatten out, and the dips on the opposite sides of the axes approach more to equality, until a general horizontality succeeds in the plain of the Ohio and its tributaries. A similar configuration, and law of progressively diminishing incurvation in the flexures, prevails it is believed in all regions of the earth's surface, where a distinctly developed system of anticlinal axes can be studied. The axes, or great flexures of the Appalachian chain, occur in natural groups; those in each group being approximately parallel, and equidistant, and coinciding nearly in length. Some of these are more than 100 miles long. The distance separating two adjacent axes in an extensive group, visibly augments as we cross them towards the N. W., in which direction the flexures, it has been said, flatten out. Professor Rogers and his brother think they have proved, that analogous relationships connect together the axes of the more disturbed regions of Europe, and that a few simple laws will be found sufficient to express the phenomena of flexures in every part of the globe.

Connecting these general facts respecting the form, parallelism, and progressively increasing distance, and flattening of the flexures, with the manifestations of analogous transient bendings of the earth's crust during earthquakes, they have suggested that all the phenomena may be united under one theory of dynamic movement. They conceive, that in those districts of the globe where the strata are much undulated, the crust was subjected to an excessive upward tension, or other internal force, causing in it extensive linear disruptions and all the phenomena of earthquakes on the grandest scale. Simultaneously with its violent oscillation, the crust would be shoved horizontally forward in the direction of the transmission of the earthquake waves, and the undulations or flexures be rendered permanent by being braced or keyed fast by the intrusion of the molten lava below into the innumerable fissures which would open. The horizontal or tangential movement would steepen the advanced side of each anticlinal wave, and every fresh pulsation would augment the amount of flexure, so that even a complete plication with folding under would finally result on that side of the region, whence these repeated and violent earthquake pulsations proceeded.

Prof. Rogers concluded by citing in support of his declaration, that the structural phenomena of the Appalachian chain extend to Europe, a letter that he had recently received from a distinguished British geologist, Prof. Phillips.

Professor Stephen Alexander, of Princeton, N. J., presented a communication "On the Physical Phenomena which accompany Solar Eclipses."

In this communication, Professor Alexander brings forward various considerations in support of the conclusions announced by him to the Society on the 15th of July last;* and as prefatory to the argument which he founds on them, he gives a synopsis of numerous observations of the phenomena in question made subsequently to the invention of the telescope. These he arranges in tabular form in the order of dates, under titles following the natural order of succession of the phenomena. The observations thus detailed and collated, are necessarily reserved for the forthcoming volume of the Transactions of the Am. Phil. Society: the following is little more than a succinct cata-

* See Proceedings A. P. S. Vol. II., May, June and July, 1842. p. 201, or the summary at the end of this abstract.

logue of the titles under which they are classed by Prof. Alexander.—They form his FIRST TABLE.

1. An appearance of a doubtful character, similar to that of a faintly illuminated limb of the moon, seen by Prof. A. in the State of Georgia, shortly before the beginning of the eclipse of November 30, 1834, and not unlike that which was observed by J. L. Memes, Esq. in England, to succeed the eclipse of September 7, 1820; both observations apparently indicating that a portion of the moon's disc was visible.

2. The appearance of a prominent dark point or points, indenting the sun's disc at the very beginning of the eclipse; observed by Sir Wm. Herschell in 1793, M. Mechain in 1794, and by others in 1836 and 1838;—and corresponding phenomena at its ending, observed by Herr Schmidt and Herr Gutkaes at Dresden in 1818, by Mr. Memes in 1820, by Mr. Rümker in 1828, and by others in 1836; and at a later period of the eclipse, an exaggerated roughness of the moon's edge, observed particularly by Prof. Weidler in 1730 and 1733, and by others in 1765, 1793, and 1820, &c. &c.

3. An appearance of dark lines on the sun's limb soon after the first disturbance; observed by Prof. Johnson at Philadelphia, in 1838;—and corresponding phenomena near the end; observed by Professor Van Swinden, in 1820, and by Prof. Johnson, Dr. Patterson, Mr. Justice and Mr. Walker, in 1838.

4. A slight bending of the cusps of the uneclipsed portion of the sun; noticed by the Prince de Croy in 1765, Dr. Herschell in 1793, and Mr. Greve in 1820.

5. A peculiar motion or agitation of the sun's light, at the edge of the moon's disc; referred to by Mr. Maclaurin as having been seen in 1736–7, and previously observed by Hevelius; observed also by Prof. Weidler in 1739 and at other times.

6. The appearance of flashes, or coruscations of light, upon the moon's disc; observed in 1715, by Dr. Halley at London, seen also at Wittemburg in 1739, and by Mr. Memes in 1820.

7. An illuminated band or seemingly brighter portion of the sun's disc, bordering the limb of the moon; observed by the author, February 12, 1831, at Berlin, in the State of Maryland, during the progress of the eclipse, with two telescopes of different powers and differently coloured screen-glasses.

8. A remarkable illumination of a solar spot "close to the moon's edge;" observed by Mr. Dawes of Ormskirk, and by Messrs. Lasell and King of Liverpool, May, 1836.

9. An isolated spot or trace of light upon the moon's disc:—the spot, observed about the middle of the eclipse of July 14, 1748, by Mr. Short at Aberdour Castle,—and during the eclipse of September 7, 1820, for nearly $1\frac{1}{2}$ min. by Mr. Memes:—the trace or stream of light also, seen by Mr. Memes, extending from each side of the macula; its entire length about 60° of the moon's circumference.—A faint but somewhat similar light was observed also by the author on the moon's disc shortly before the total obscuration, Nov. 30, 1834.

10. Projection of the visible edge of the moon's disc beyond the solar cusps; observed at London, in June, 1666, by Mr. Willoughby and others; at Nuremberg in Sept. 1699, and at different places in 1715, 1748, 1816, 1820, and 1831.

11. Peculiar colour of large continuous portions of the moon's disc: —its edge pale like clouds, the middle of the disc black, as described by Wolf in 1706: black with a blue girdle, as seen by Prof. Weidler in 1727: the same appearance with an interior girdle of reddish purple, seen by the same observer in the eclipse of 1730: the blackness of the disk tinged with red, as seen by him July 1739: a dusky grey orb, somewhat brighter towards the sun, seen by M. Schroeter in 1793: reddish purple, gradually darkening to the centre, which was black, as seen by F. Baily Esq. and Mr. Veitch during the existence of the annulus, in May, 1836, with refractors and red screen-glasses.

12. Illumination, with greater or less distinctness, of a crescent of the moon's disc: observed by M. de Ferrer at Kinderhook in June 1806, just before the emersion from the total eclipse; the colour palish yellow: observed also by Mr. Garnett at New Brunswick, N. J. Mr. Hassler at Washington in Feb. 1831, noticed the "inequalities of the moon" by the "reflected light and shade" upon the $\frac{1}{3}$ of its disc when the moon was about $\frac{1}{8}$ immersed towards the beginning and end of the eclipse.

13. Greater or less illumination of the entire disc of the moon at the time of total eclipse: it appeared uneven and rough, and of a saffron hue to Prof. Waller at Upsal in 1715: Vassenius at Gottenburg in 1733 saw the spots in the disc: M. Arago at Perpignan, and Mr. Airy on the Superga in 1842, saw the whole disc illuminated.

14. The appearance of separate portions of the sun's disc, usually in the form of drops of mercury, with intervening spaces of greater or less extent; these spaces sometimes seeming to be afterwards drawn out into narrow dark lines. These phenomena having been seen only when the uneclipsed portion of the sun began to present

very fine cusps: noticed by Prof. Heinrich at Breslau in 1706, by Halley at London in 1715, by several observers in Scotland in 1736–7, at Elgin in 1748, and at different stations in 1764, 1780, 1791, 1806, 1820, 1831, 1834, 1836, 1838, and 1842.

15. Red colour of a small fragment of the sun's disc, the only portion remaining uneclipsed: remarked by Mr. Shelton near Pontefract, April 22, 1715.

16. An apparent distortion of the moon's disc on the same side with the dark lines already described (No. 14), and cotemporaneous with them: observed by F. Baily, Esq., 15th May, 1836.

17. The sudden formation of the annulus, which at once had sensible breadth: remarked whenever the *drops* had been seen, and the eclipse was not far from central.

18. The comparatively faint light of the remaining fragment of the sun's disc just before it suffered a total eclipse; noticed by Dr. Halley and others at London, April 22, 1715, and Messrs. Pinnaud and Boisgeraud at Toulouse, July 8, 1842,—and the seeming disappearance of such a portion of the disc, and its subsequent reappearance just previous to its total immersion; noticed by Mr. Airy upon the Superga, July 8, 1842.

19. A succession of shadows upon the surface of the landscape, "*like the rippling waves upon some shallow pond*," seen about the time of the total eclipse of June 16th, 1806, by Mr. Crookshank and others in the interior of the State of New York: also the progress of the shadow; which was observed by M. Duillier at Geneva in May, 1706; according to Dr. Haley, at Brightling, Sussex Co., in April, 1715; by M. Lorenz, in Lemberg, Nov. 1816; at Beaufort, S. C. by R. T. Paine, Esq., Nov. 1834; at Turin in 1842 by Professors Plana and Forbes.

20. A corona of variable extent, and essentially, it would seem, of a white colour, surrounding the moon during a total eclipse, and in some rare cases when the eclipse was not quite total; when most extensive, the outer parts of the corona less brilliant than the inner: observed at several places on the continent of Europe in May, 1706, at London and Upsala in April, 1715, at Gottenburg in 1733, and also at several stations in 1778, 1806, 1816, 1834, and 1842.

21. Various colours exhibited by the corona:—ruddy bright, and as a ring of gold, at Zurich, in 1706, to Scheuzer and to Wurzelbaur at Nuremburg; pale white or pearl, a little tinged with colours of iris, to Dr. Halley in 1715; reddish, changing to pale yellow; pearl colour; and nearly white, with a tinge of peach colour; to different observers in 1778, 1806, and 1842.

22. Apparent motion in the corona: a fluctuation or trepidation about the limb of the moon at Barcelona in 1628, seen also by Tschirnhausen at Dresden in 1706; a whirling motion, seen by Don Ulloa in 1778; a clear unsteady light, according to Von Stölpe, in 1816; vivid and flickering, as seen by Mr. Baily in 1842.

23. The appearance of small isolated spots or beams of light, coloured or otherwise, at various points of the moon's edge, at the time of a total eclipse, often of exceeding richness and beauty of tint; variously described as "reddish spots," "red flames," "illuminated Alps," "fiery mountains," "rocks of incandescent crystal;" remarked by Vassenius at Gottenburg, May 3, 1733; and with very interesting variety by several observers in America and Europe, Nov. 30, 1834, and July 8, 1842. Like phenomena were seen between the cusps, the eclipse being in most cases nearly annular, by Mr. Short at Aberdour Castle, July 14, 1748; and in Sept. 1838, by the author and Prof. Henry at Princeton, N. J., Mr. Gummeré at Haverford, Pa., Prof. Johnson, Mr. Walker, and others at Philadelphia, with red, yellow, and greenish-yellow screen-glasses. In this last eclipse, Dr. R. M. Patterson at Philadelphia saw a beam of light between the cusps for four minutes fifty-three seconds after the rupture of the ring: the same was noticed at Princeton by the author and Prof. Henry, through a Dollond telescope with red screen glass, but was not seen when a much superior instrument of Utschneider and Fraunhofer was used, of which the screen-glass was greenish-yellow.

24. "Very slender columns of smoke" apparently issuing from the western limb of the moon during a total eclipse, as observed by M. de Ferrer at Kinderhook, N. Y., June 16, 1806 (perhaps a modification of the foregoing, No. 23).

25. The appearance of a brilliant spot within the moon's disc after the total immersion of the sun, and previous to its visible emersion at the moon's limb; noticed by several observers in 1778, 1806, and 1842.

26. Several luminous appearances, each of which has at some time preceded the sun's emersion from a total eclipse,—and the analogous phenomena which have been seen when the eclipse was all but annular:—such as the increase of light in the atmosphere for about two seconds before the sun's limb was visible, noticed by Dr. Bowditch and others in June, 1806,—the ribbon of white light concentric with the sun, nearly fifteen seconds before the emersion observed by M. de Ferrer in June, 1806, and about eleven seconds before

the emersion observed by the author in Nov. 1834,—a narrow band of red light occupying the same position,—a bright gleam of light, sometimes red, sometimes purple, between the cusps, when the eclipse was nearly annular, sometimes before the formation, and sometimes after the dissolution of the annulus, all of which have been often observed.

27. The peculiar colour of the sky, the appearance of the clouds, &c., and other indications of the loss of light during the progress of a total eclipse, and of the character of that light which remained; particularly described by Dr. Halley in the instance of the eclipse of April 22, 1715; by Messrs. Pinnaud and Boisgeraud at Toulouse, July 8, 1842; by the author in Nov. 1834, &c. &c.

28. A manifest *increase* of light soon after the total obscuration of the sun on June 24, 1778, and a subsequent and apparently corresponding *decrease* previous to the sun's emersion at the edge of the moon's disc; witnessed by Don Ulloa.

29. Indistinctness of the prominent points at the edge of the moon's disc near the end of an eclipse, and an apparent adhesion of the disc to the surface of the sun,—followed by a *sudden* termination of the eclipse,—described by J. L. Memes, Esq., in his account of the eclipse of Sept. 7, 1820. The two latter phenomena were also seen by Mr. Andrew Livingstone at Gibraltar.

30. Change in the relative extent and brilliancy of the different colours of the solar spectrum,—the yellow and blue rays being in one instance increased in brilliancy, and the red becoming faint and of reduced breadth; observed at the eclipse of Sept. 7, 1820, at Norwich, Eng., and by Mr. Paine in Massachusetts at that of Feb. 12, 1831: Messrs. J. and S. R. Gummeré at Burlington, N. J. thought that the violet, though very bright, was rather paler than at other times.

31. Effects attributed to irradiation and inflexion;—observed repeatedly by different astronomers.

32. Heat of the sun's rays which remained unobstructed; and various effects upon the temperature, pressure, &c., of the atmosphere, as observed during sundry eclipses of notable size;—including very numerous experiments with burning glasses, observations with Leslie's photometer, indications of the thermometer exposed to the sun and in the shade, and of the barometer, observations on the deposition of dew and the variations of the dew-point, the condensation of vapour, and other atmospheric changes.

33. Magnetic variations; observations of the needle by Col. Beaufoy, Sept. 7, 1820, Mr. Gummeré at Burlington, N. J., Feb. 12, 1831, Mr. Nicollet at Milledgeville, Geo., Nov. 30, 1834.

Professor Alexander exhibited drawings on a large scale of several of the appearances described under these heads, and presented a list of several publications in which others are represented. He remarked that some of the observations which he had noticed, might be regarded as of little value, and that some were probably referrible to ocular deception; that perhaps too, separate places had been sometimes assigned to phenomena which were only modified effects of the same cause; while others had been grouped, because presenting themselves at like periods and seemingly resembling each other, which might yet prove to be essentially different. He observed that he had kept one uniform rule in view: viz. *not to reject any thing which might be of use; but when it rested on sufficient evidence, to present it distinctly, free, as far as possible, from the bias of any preconceived notion, with regard to its reality or its cause.*

He observed that in accounting for many of the phenomena, it should not always be his object to advance a satisfactory theory, or perhaps even a stable hypothesis, but to attain to what might be termed an incipient generalization, which should so group the phenomena, that though he might fail to point out their cause, he might at least show wherein such cause must reside.

He adverted in the first place to the supposed action of a lunar atmosphere as the most obvious cause of some of the phenomena, and inquired how far such an atmosphere would be favourably or unfavourably situated for producing them. As the moon always presents nearly the same face to the earth, whose mass far exceeds her own, an aëriform fluid covering the entire surface of that satellite would be subjected to a great terrestrial and anti-terrestrial tide, whose position would be subject to but little variation. The tide producing energy at the moon would be about 158 times as great in its intensity as the like action of the moon upon the earth. The action of the sun would also combine with that of the earth at new and full moon; so that the result of both would be to accumulate a great tide wave above the central portion of the disc, and another on the opposite invisible side; thus leaving the edges comparatively destitute, and most so at the time of an eclipse. If therefore the moon be surrounded by an atmosphere, we are most unfavourably placed for the study of its effects.

The question of the existence or non-existence of a lunar atmosphere however is not a primary one in this connexion; and Professor A. proceeds to inquire, what are the laws which regulate the action of the moon upon the light passing near her border. To aid in determining these, he forms a SECOND TABLE of the peculiar phenomena which have been observed to accompany certain occultations of planets and fixed stars. These he classes under titles and with an arrangement similar to those observed in the table of phenomena of solar eclipses. The following is a condensed abstract of these titles:

1. An apparent projection of a fixed star, or of a planet or some portion of a planet on the moon's disc; remarked at two occultations of Venus by La Feuillée in 1722, and M. Thulis at Marseilles in 1796, at the occultation of Jupiter and his satellites by Mr. Ramage at Aberdeen in April, 1824, at an occultation of Uranus by Captain Ross in August, 1824, at twenty-six occultations of fixed stars recorded in Sir J. South's table, in Vol. III. Part II. of the Memoirs of the Astronomical Society of London, and at occultations of Aldebaran and other fixed stars, observed by the author and others.

2. A distortion of the disc of a planet, or of the false disc of a star: observed at the occultation of Venus in Sept. 1729, by C. Kirch at Berlin; of Jupiter in April, 1824, by Mr. Ramage at Aberdeen, and by the author and others at different times; of Saturn in Oct. 1825 by R. Comfield and J. Wallis; and of fixed stars in several instances.

3. A division of the illuminated disc of a planet into two parts, and their subsequent reunion at the instant of complete emersion; witnessed by M. Thulis at the occultation of Venus, Nov. 1799.

4. Apparent adhesion of stars to the moon's edge; of which twenty cases are recorded in Sir J. South's table; observed too by Maraldi in 1718, Cassini, De la Hire, and others.

5. The gliding of a star along the moon's edge previous to its immersion: three instances of which are recorded by Sir J. South; observed too by M. Ideler, at Berlin, in 1792.

6. A tremulous motion of a star just before the immersion, as seen by the author for two seconds in the case of γ Tauri in 1831, or immediately after the emersion as seen by M. Flaugergues, Sept. 1796.

7. A seeming emersion of some portion of the disc of a planet, and its subsequent occultation; observed in Russia by MM. de la Croyére and De l'Isle at the occultation of Mars, Jan. 1726.

8. An apparently sudden and violent motion in the star as it disappeared at the immersion, and a like rapid separation from the moon's

limb at the emersion, observed in several of the cases already mentioned, in which the star was projected on the disc, and in one case by M. Ideler at Berlin in 1792.

9. An apparent diminution in the brightness of a planet or fixed star a little before the immersion and for a short time after the emersion. This was noticed by Capt. Ross in August, 1824, at the immersian of Uranus, at the emersion of Saturn in June, 1762, by Mr. S. Dunn, and at the immersion or emersion of fixed stars, five instances of which are mentioned in Sir J. South's tables, and others were observed by the author, Prof. Henry, and other astronomers.

10. Disappearance of a star at a sensible distance from the moon's limb previous to any ordinary immersion, observed by Dr. Maskelyne, Dec. 1779, and the corresponding phenomenon at the reappearance of a planet or fixed star; observed by Capt. Ross at the occultation of Uranus in Aug. 1824.

11. A change of colour in the light of a star at the immersion or emersion; of which seven instances are noticed by Sir J. South and others.

12. A faint impression or brush of light just after a star had vanished at the immersion; observed by Dr. Maskelyne and by the author.

To this catalogue of phenomena attending occultations, Prof. A. adds a THIRD TABLE, embracing certain luminous appearances observed on various occasions upon the moon's disc. These may be abstracted thus:

1. A faint line extending beyond the sharp cusps of the illuminated part of the moon's disc, at certain periods near the time of new moon; observed by Mr. Schroeter at Lilienthal, and ascribed by him to a lunar twilight.

2. A luminous arch completely uniting the cusps, soon after new moon; observed by Kolben in 1705 and by Siegesbee.

3. Luminous spots having a fiery appearance, which have at different times been seen upon the dark hemisphere of the moon; mentioned by Dr. Herschell and by M. Schroeter, and referred by them to volcanic action.

4. A peculiar band of light extending across a portion of a solar spot, which seemed to be inaccessible to the sun's rays; first observed by Bianchini in 1725, extending from the illuminated margin across the middle of the spot Plato, and subsequently in 1751 by Mr. Short, Dr. Stephens, and Mr. Harris, who saw two such streaks across the

same spot; one of which was afterwards again divided: they also saw two gaps in the mountainous margin, directly interposed between the streaks and the sun.

5. Unusual tints of light, and tinted shadows, seen at certain spots, which at the time were situated near the terminator or boundary of lunar day and night; mentioned in Beer and Mädler's Selenographie, p. 153.

From these Prof. A. passed to phenomena attending the transits of Venus and Mercury, some of which have been recognised as bearing a strong resemblance to those observed during eclipses of the sun: These also he has arranged in tables. The following is a summary of his FOURTH TABLE, embracing phenomena noticed at transits of Venus:

1. "A kind of lucid wave" of an imperfectly transparent character, which gave the first intimation of the approach of the planet; observed by Mr. Dunn at Greenwich in 1769.

2. An apparent ferment or boiling following the foregoing phenomenon, at the same place of the sun's limb, and continuing for some seconds till the limb of the planet was seen to enter; also observed by Mr. Dunn in 1769, and with slight variations by Bevis at Kew, Hirst at Greenwich, and others.

3. Nearly cotemporaneous with this last appearance, a "watery pointed shadow" was seen by Dr. Smith at Norriton, a shadow with irregular notched edges by Mr. Shippen at Philadelphia, a dusky appearance by Dr. Williamson, and an obscuration gradually advancing by Mr. Ewing, both at the same place, a penumbra by Mr. Horsfall at London, &c.

4. The first visible impression of the dark body of the planet in most cases presented nothing remarkable.

5. A border of light around that portion of the planet which had not yet entered upon the sun's disc, was seen by Mr. Rittenhouse and other observers at Norriton and Philadelphia in 1769, by Dr. Maskelyne and others at the same transit, and in 1761 by M. Bergman and M. Mallet at Upsala.

6. A distortion of the portion of the planet's disc which was on the sun after partial immersion:—the notch appearing to Mr. Hirst at Greenwich, in 1769, to be rough, and as if a portion of a much less sphere; and the planet assuming an oval or elongated appearance, to Dr. Wilson at Glasgow, M. Ferner at Stockholm, and M. Mallet at Upsala.

7. A distortion of the cusps of the sun previous to the internal contact; observed by M. Mallet at Upsala in 1761.

8. "A partial and very faint illumination, both a little without and a little within the sun's limb, as well as in the limb itself, where the contact was to be," when the outer edge of Venus had come near to the sun, and the border of light around it had vanished; observed in 1769 by Mr. Dunn at Greenwich and Mr. Canton at London.

9. A renewed ebullition, succeeded by the formation of a ligament, penumbra, or a black drop, &c., extending from the body of the planet, so as to conceal the sun's limb; thus delaying as it were the internal contact; noticed by Messrs. Hirst and Dunn at Greenwich in 1769, and with more or less accordance by very numerous observers in Europe and America: it was noticed also in 1761 at Upsala, Madras, and elsewhere.

10. A feeble illumination, with more or less violent agitation of various parts of the ligament above mentioned, which in one case seemed to consist of "many black cones or fringes;" particularly noticed by Mr. Dunn in 1769, and M. Mallet at Upsala in 1761; noticed also by others.

11. A continued agitation, brighter light, and the frittering away or dissolution of the ligament; described by Mr. Dunn in 1769, Dr. Smith at Norriton, and several others.

12. The completion of the thread of light: in 1769, as seen by Mr. Dunn, it succeeded immediately the changes last described; at Norriton, according to Dr. Smith, the points of the luminous thread closed, but at first with imperfect light; at Philadelphia the continuous thread had to Mr. Pearson a tremulous motion; Dr. Maskelyne saw a fine stream of light flowing gently round; Mr. Horsfall at London a lambent light whirling round the opaque limb; and the thread, when complete, appeared to different observers in 1761 and 1769 to be one-sixth, one-eighth, and one-tenth of the diameter of Venus in breadth.

13. A distortion of the disc of the planet after the dissolution of the ligament, when the whole disc was visible on the sun, was observed by Dr. Maskelyne at London in 1769, and at several other astronomical stations.

14. A glimmering light about the part of the planet which had last entered upon the sun's disc; seen by Mr. Hirst, 1769.

15. A purplish-coloured light on the northern side of Venus, which endured for six or seven minutes, was observed by Mr. Horsley at Greenwich in 1769.

16. A narrow luminous circle, seen at different times during the transit, while Venus was wholly on the sun; by Mr. Hitchins at Greenwich and by Mr. Dunn in 1761, and M. Ferner near Paris and M. Lulofs at Leyden; the last of whom says, that it disappeared when the sun's light became intense enough to require coloured glasses.

17. An eccentric ring of light around Venus, having a gentle fluctuating motion, seen by Mr. Mason at Cavan, 1769.

18. A seeming illumination of the disc of the planet, noticed by Mr. Dunn, 1761.

19. The reappearance of the black drop, &c. (noticed above, 9), at the second internal contact, was observed by Mr. Wales in 1769 for twenty-four seconds as a protuberance, as a penumbra by the Earl of Macclesfield, as a ligament at Upsala in 1761, and a black drop at Wardhus in the same year.

20. A protuberance of the edge of the sun's disc at the first external contact, surrounding Venus on all sides by its margin, which appeared to be a little elevated beyond the planet: followed moreover by a distortion of the cusps when the intervening thread of light had disappeared. This was observed in 1761 by M. Mallet at Upsala.

21. The distortion of a portion of the planet's disc, which still indented the sun after the first external contact; observed by MM. Stroemer and Mallet at Upsala in 1761.

22. Luminous appearance around a part of the planet, which after the first external contact was observed to extend beyond the sun's disc; noticed in 1761 by MM. Mallet and Bergman at Upsala, and by M. Wargentin at Stockholm.

23. A sharp indentation just before Venus suddenly left the sun; observed by M. Mallet at Upsala in 1761.

24. A somewhat faint penumbra or ligament, after the egress of the dark disc of the planet; observed by M. Bergman at Upsala in 1761.

Phenomena somewhat similar to those mentioned in the foregoing table have also been occasionally observed during the transits of Mercury; but they have been of comparatively rare occurrence. They have not escaped notice through inattention; as they were looked for very carefully in various instances, especially at the transit of 1769, which occurred but a few months after the last transit of Venus, and that of 1802, which was observed with scrupulous care and under most favourable circumstances by Dr. Maskelyne. The phenomena which have been exhibited at the transits of the smaller planet form Prof. Alexander's FIFTH TABLE.

1. The appearance of something like a penumbra at the first external contact; remarked by Prof. Williams at Harvard University, Nov. 12, 1782. The appearance was not that of the contact of two circles, nor like a well defined black spot entering upon the sun, but rather like a dark oval shadow entering and mixing with the sun's limb.

2. The appearance of a black drop or ligament, or of a cohesion, previous to the completion of the thread of light at the first internal contact. (See Bode's Jahrbuch for 1803, pp. 109 and 198, and Mem. Astr. Soc. Lond. Vol. VI. p. 198.)

3. Apparently elliptical form of Mercury's disc when near the sun's limb,—noticed at or soon after the ingress, in Nov. 1723, and Nov. 1736, by several European observers, by Prof. Williams at Harvard in Nov. 1782, and by Dr. Madison of William and Mary College in Nov. 1789,—at or near the egress, at Nuremberg in Oct. 1690, at Vienna in Nov. 1697, at Louvain in May, 1786,—at both the ingress and the egress, by President Willard of Harvard in Nov. 1782,—and at a period of the observation not recorded, in May 1799 by M. Flaugergues at Viviers.

4. A luminous ring around the disc of the planet; seen by M. Plantade in Nov. 1736 during the entire period of the transit and for some seconds thereafter, by Mr. Short in 1736 and 1743 as a luminous corona, by M. Prosperin in May, 1786, by the assistant of Dr. Maskelyne at the same transit, by M. Eimbecke at Hamburg in May, 1799, and by the author himself at Albany, N. Y. in May, 1832, without a dark glass, through thin, though dark, flying clouds.

5. A dark nebulous ring around the planet; possibly a modification of No. 4; seen by M. Schroeter in 1799, by M. Ljunberg in 1802, and by Prof. Moll in 1832.

6. Peculiar appearances on the disc of the planet; described and figured by Wurzelbaur of Nuremberg, Nov. 1697, as a minute globule, not perfectly round and of graded intensity of light, darker at the lower section, very bright at the upper, and with shaded brightness between: Prof. Mole saw an imperfectly defined spot upon the disc in 1832.

7. Reappearance at the egress of the black drop, or of an apparent adhesion; spoken by Prof. Jungnitz of Breslau and M. Köhler of Dresden.

8. A seemingly rapid motion, and sundry changes in the appearances, at the second internal and external contacts, as seen through various screen-glasses. Reference is here had particularly to the observations of M. de Barros made at Paris in May, 1753, with an excellent Gregorian reflector, his smoked glass being fixed in a close tube, perpendicular to the axis of the telescope. After noting the interior contact through a green glass held over the smoked glass, he found, on using the smoked glass only, that a thread of light was visible between the limbs for four seconds after; the exterior contact too seemed stationary for six or seven seconds; and after the total egress had been seen through the combined glasses, Mercury was again seen on the sun through the smoked glass alone for six or seven seconds, &c. &c. Whether all these observations could have been completed in so brief an interval, has been seriously questioned.

9. A change of form in the indentation as Mercury was retiring from the sun's disc, followed by an adhesion, or by something like a fine dark ligament, which suddenly disappeared at the last external contact. In Nov. 1690, M. Warzelbaur observed this adhesion after the planet had recovered its roundness, and in 1697 this distortion and its sudden disappearance.

With reference to the question, whether the phenomena, described in the two tables immediately preceding, ought to be referred to the peculiar action of the planets themselves, Prof. A. turns to the phenomena which they have exhibited under other circumstances. Those of Venus, derived principally from the writings of M. Schroeter of Lilienthal, and Dr. Herschell, but in part from the works of others, and from his personal observations, form a SIXTH TABLE.

1. A manifestly superior brightness of the limb of the planet, which usually was observed to diminish with no little rapidity towards the interior edge of the illuminated surface,—a common observation of M. Schroeter; mentioned particularly by Dr. Herschell in 1793; seen by the author in Oct. 1839.

2. Appearance of a dark spot or spots upon the bright portion of the disc; observed by Fontana in 1645, Cassini in 1666, and others in 1726, 1727, 1728, 1783, 1799, 1820, and 1840.

3. Uneven edge of the terminator or boundary of day and night; observed by Fontana in 1645, Cassini in 1667 and 1668, and others in 1700 and 1822, and by the author in Oct. 1839.

4. Variety in the apparent form of the cusps of the enlightened portion of the disc; one appearing to be sharp and the other round, or both of them round; noticed especially when the planet was near to its greatest elongation;—observed at different times by M. Schroeter, M. Tischbein, and Dr. Chladni.

5. A bright projecting point in the terminator, near the northern round cusp; seen on one occasion by M. Tischbein and M. Schroeter.

6. Intrusion of a distinct dark point from the edge of the terminator into the illuminated hemisphere: also faint shades between the asperities of the terminator;—observed by M. Schroeter, Dr. Chladni, and Dr. Olbers, on different occasions. On one of these occasions, 27th Feb. 1793, the dark point, such as had been noticed near the southern cusp the day before, was seen by M. Schroeter to extend itself, "during the observation," entirely across the cusp; so that in eleven minutes the end of the cusp "passed very evidently to the form of" No. 7.

7. "A separate point of light" beyond the apparent end of the cusp:—seen on other occasions also by M. Schroeter.

8. Peculiar form of one or both of the sharp cusps of the enlightened portion of the disc, when the planet was near the inferior conjunction:—bent apparently inward in the form of a hook, as seen repeatedly by M. Schroeter in 1790, and by the author in Oct. 1839: —or turned outward in the direction of a tangent, as seen by the author in the same month.

9. Faint termination of one or both of the sharp cusps, which were not unfrequently prolonged beyond the limits of a hemisphere; observed and measured by M. Schroeter in 1789, 1790, and 1793, also by Dr. Herschell, and in 1839 by the author.

10. Apparent deviation from a regular curvature in other portions of the limb, at a time when Venus was near to the inferior conjunction; observed by M. Schroeter in 1790, and by the author and others in 1839.

11. Projection of a long continuous portion of the terminator beyond its general outline (a seeming exaggeration of No. 3),—noticed by M. Schroeter in 1793, and by Herr Pastorff in 1820.

12. Visibility of the whole edge of the obscure part of the disc, when the brightly illuminated part presented the usual appearance of a crescent; the planet being not very far from the inferior conjunction:—observed by Herr Pastorff.

Mercury also has occasionally exhibited phenomena of similar character; these Prof. A. arranges in a SEVENTH TABLE.

1. Two manifest inequalities in the outline of the limb near the southern cusp; resembling the mountain Dörfel, when it is seen on the moon's edge:—observed by M. Schroeter in 1800.

2. Shadows of mountains:—so regarded by M. Schroeter.

3. Roundness of the southern cusp; and cotemporaneously—

4. A bending or other irregular form of the northern cusp; observed by MM. Schroeter and Harding in 1800.

5. Apparent variation in the intensity of the planet's light;—invisible on one day at the time of its meridian passage, though the weather was favourable; yet visible distinctly the day before and the day after; as remarked by M. Vidal in Jan. 1799;—whose observation is confirmed generally by M. Bode.

Having arranged in this manner the phenomena which are to be considered, Prof. A. passes to an inquiry into the origin of the broken cusps, dark spaces and lines, brilliant drops, &c., described in the 14th paragraph of Table I.

He adverts first to a suggestion of Mr. Airy, the English Astronomer Royal, in the account of his observations on the total eclipse of July 8, 1842. Mr. Airy had been looking carefully with the darkened glass upon the eye-piece, and had satisfied himself that the sun had entirely disappeared. He was proceeding to note the time, when his companion asserting that to him it was still visible, he recurred to the telescope, and again saw the narrow ring of the sun's disc, though not quite so bright as before, and saw the moon's limb again advance and cover it. The explanation which he proposes, but not very confidently, is, that the light of the sun's disc, very near to its limb, being considerably less than in those parts of the disc which are farther from the limb; the interference of a cloud, sufficiently dense to hide the faintest part of the limb but not to hide the brighter parts, would sensibly lessen the sun's diameter; and that in fact such a faint cloud was seen upon the sun at the time of his first apparent extinction, which, though not sufficient to conceal the edge of the sun's disc from the naked eye, might yet have concealed it from an observer through the telescope, in which the specific brightness is always less than it is to the naked eye, and which in the observed case was armed by a dark glass. Mr. A. adds, that before this he had referred the notches in the sun's limb to irregularity of refraction; but that these, and perhaps too the beads observed by Mr. Baily, may have been due to irregularities in the transparency of the atmosphere.

The comparatively feeble light of the sun's disc near the limb had been already deduced by M. Bouguer from observations made by himself; and both M. Mallet and Mr. Short had alluded to the imperfect transparency of the atmosphere, as among the causes to which certain phenomena attending transits of Venus and Mercury might be referred. The suggestion of Mr. Airy may perhaps derive additional force from other considerations which Prof. A. mentions:—

1. That the appearances in question may be styled local phenomena; they having been seen by observers at certain places, but not by cotemporaneous observers at others.

2. That an imperfectly transparent medium of another kind would seem to have an effect on the visibility of these phenomena:—Mr. Paine having remarked, that through a double screen, composed of one light red and one light green glass, which he employed in observing the partial eclipses of 1832 and 1836, and those which were central in 1834 and 1838, "no one of the irregularities described by Mr. Baily has ever been perceived;" though observers in his vicinity through other screens saw in 1834 many or most of the usual phenomena, and they have frequently been seen through screens of other colours than red.

3. M. de la Hire observed, that when the sun was artificially eclipsed by an unpolished globe of stone, the interior of the ring that was formed around it was broken and uneven. Prof. A. remarks, however, that it is not stated whether any portion of the actual disc was exposed in M. de la Hire's experiment; and that the appearance may perhaps admit of some other explanation.

Yet, Prof. A finds it difficult to apply Mr. Airy's suggestion to the phenomena immediately in question, because :—

1. Although the light received from the central portion of the sun's disc may be, and very probably is, characteristically different from that of the limb, yet this difference does appear to be one of *intensity.* For when experiments are made with a photometer, constructed with reference to the properties of polarized light, in which are employed two partially or entirely superimposed images, the light produced at the points of coincidence is found to be perfectly white; from which it follows, as has been remarked by M. Arago, 1. that the light of the parts near the limb is as intense as that of the centre; 2. that the colours of the images are complementary each of the other. Professor Bache's experiments at Philadelphia during the solar eclipse of 1831,

with a Leslie's photometer, also point to the conclusion, that the heat at least, if not the light, which proceeded from the region near the edge of the disc, was of the average intensity.

2. The phenomena in question do not seem to have been visible to Mr. Airy under the very circumstances that suggested his explanation; though before the sun finally disappeared, he "saw the narrow ring" of his disc "not quite so bright as before."

3. The relatively faint "umbræ" or shallows, which usually surround the solar spots, do not exhibit a broken outline, though they continue to be visible, when near the sun's limb, and the limb is very seldom indented as they enter upon or leave the disc; facts not reconcilable with the proposed explanation.

4. These phenomena have been observed "only in the proximity of the borders of the sun and *moon*."

5. The progress of these phenomena seems to be not independent of the moon's position, since in 1836 especially, as the moon advanced, the dark spaces became narrower as well as longer. This might be referred to increased irradiation, as more of the sun was then exposed: but—

6. The scars or indentations of the moon's disc, produced by the apparent intrusion of portions of the sun at the formation of the drops, are not increased at the formation of the annulus; but on the contrary, the thread of light is not as wide as the drops that precede it.

7. Similar and seemingly analogous phenomena have been observed during the transits of Venus; and this, not only when the sun was near the horizon, and his limb somewhat unsteady, but when he was near the zenith, his limb perfectly defined and free from tremulousness, and the air remarkably serene and clear.

8. The progress of these analogous phenomena seems to have been not independent of the motion and position of the planet; as is shown by the first nine paragraphs of Table IV.

These considerations, which Prof. A. amplifies and supports by numerous references, lead him to the conclusion, that the imperfect transparency of the atmosphere, though not inappropriate, and though perhaps under certain circumstances not inefficient, is not *adequate* to the production and explanation of these phenomena.

He rejects for the same reasons the supposition that they are due to irregularities of terrestrial refraction; and considering the notion that they have their origin in peculiarities of vision or the imperfections of telescopes, as fully negatived by the number and character of the observers, and the variety and excellence of their instruments, he determines, 1. that the causes of the phenomena must be sought for beyond the limits of the earth's atmosphere, and 2. that, as no efficient intervening medium is known to exist, they must reside either in the sun or in the moon.

He then gives a summary of the reasonings, which would refer them to the action of a solar envelope; 1. that it is at the sun's edge, (where of course such an envelope should have the greatest effect) that the phenomena have been seen almost exclusively, and 2. that when similar appearances have been observed at the transits of Venus and Mercury, the planet has also been, almost without an exception, at or near the edge of the sun's disc. But he regards these, as opposed successfully, 1. by arguments founded on the photometrical observations already referred to: and by the additional considerations, 2. that the phenomena are not visible alike at all places where the eclipse is visible, though circumstances be otherwise favourable: 3. that the appropriate effect of such an envelope is not observed on the umbræ of the solar spots: 4. that should such envelope be atmospheric, there would probably be a displacement of the solar spots by refraction as they recede from the centre; and no such change has been observed: 5. that the hypothesis leaves unexplained the diminished depth of the indentations of the moon's limb in the formation of the complete annulus.

The 2d and 5th, and possibly also the 3d of these objections apply equally to the somewhat analogous supposition, that the phenomena are due to a characteristic difference in the properties of the solar rays, proceeding from the outer and from the central portions of the disc. Prof. A. adverts incidentally, and somewhat at large, under this head, to the well devised and highly successful observations of M. Bessel on the eclipse of May, 1836, and afterwards; by which he has established the existence of a very bright envelope of moderate extent about the sun. He refers too, to the conjecture of Herr Beer in 1833, that there was such an envelope, and to the "ribbon of light" observed by M. de Ferrer in 1806, and similar appearances witnessed by himself in 1834, as also indicating its existence. But he does not regard these views, as having sufficient claims to explain the phenomena under consideration; especially in view of the fifth reason exhibited in the preceding paragraph.

Prof. A. next reviews several other hypotheses, which have been offered in explanation of the phenomena of Table II., especially of those which form paragraphs 1 and 4. Most of these, he remarks, have been well disposed of by Sir James South. Two of them, implying illusion on the part of the observer, or defect in his instrument, have been already noticed while discussing the phenomena of Table I.: Sir James South speaks of it as remarkable, in reference to the latter of these suggestions, that the *only* case of anomaly, contributed by the Royal Observatory at Greenwich, was observed through a telescope with a forty-six inch triple object glass, which has usually been supposed to show a remarkably small image of a star. The third hypothesis,—that of a lunar atmosphere,—Professor A. hesitates to admit; and he quotes in regard to it the remark of Sir James South, that "if such an atmosphere do exist, its effects must be the same upon all stars of a similar colour," and should be expected "at every occultation which occurred:" yet the instances are "almost infinitely few," in which a star undergoes either "derangement of position, diminution of splendour, or change of colour," at the moon's approach. He gives the argument on this point in the words of Sir James; noticing however, by a reference to paragraphs 1 and 2 of Table II., the inaccuracy of Sir James's statement, that "occultations have never been preceded by a distortion of the planet," and that "an overlapping of the planet's limb on that of the moon is as yet an unknown phenomenon;" and on the whole, he appears to adopt the conclusion of that astronomer, that "amongst the immense mass of observed occultations, the existence of a lunar atmosphere, even of extreme tenuity, is so feebly supported," that it cannot be considered as adequately proved. The fourth hypothesis, that of irradiation, he rejects, with Sir James South, because instances occur sometimes of projection on the dark disc; as on the 9th Sept. 1718, when according to Maraldi and others, the immersion of a *small* star took place about the very middle of a total eclipse of the moon, and yet an adhesion to the edge of the disc was seen for several seconds. So also the fifth, viz. the "difference in refrangibility of the rays from the moon and those from the star, arising from their difference of colour;" because white stars have been apparently projected on the disc as well as red, and Mars, though peculiarly red, has not been so projected. The sixth hypothesis, that of M. de Mairan, supposes a lunar atmosphere less dense than the ether in which "this planet" floats, and attributes the phenomena of projection to a negative diffraction or inflexion :—this may be characterized rather as a conjecture than an opinion, and is not sustained by known facts.

The conclusion to which Prof. Alexander arrives upon this review, is that in the present state of our knowledge we are not prepared to assign the physical cause or causes of the phenomena in question. He thinks however, that many of those which have been arranged in his tables, exhibit a seeming conformity to two distinct laws, which *govern*, if they do not *regulate*, the action of the moon upon the light which passes near her surface. He expresses these laws in the following terms:—

LAW I. On the near approach of the moon, a minute beam of light is, in some cases, bent into a physical curve, the direction of which is *concave* towards the surface of the moon, in the region in which the beam escapes from her influence. As the moon advances, this flexure within certain limits increases; and when it has arrived at its maximum, the beam is cut off: the process being inverted in the case of an emerging beam.

LAW II. In other cases, or in the neighbourhood of other portions of the moon's limb, a minute beam of light is sometimes bent into a physical curve, the direction of which is *convex* towards the surface of the moon, in the region in which the beam escapes from her influence. As the moon advances, this flexure within certain limits increases; and when it has arrived at its maximum, the beam is cut off: the process being inverted in the case of an emerging beam.

For the sake of brevity, Prof. A. speaks of this action, when the curve is concave towards the moon, as a *distortion outward*,—when convex, as a *distortion inward;*—and for the two, he sometimes uses the phrase the *distorting action of the moon*. The distortion outward is represented on the next page, by figure 1, and the distortion inward by figure 2; both being of course enormously exaggerated in these representations.

Professor A. further qualifies the laws thus expressed, by observing that each is *local* and *specific* in its operation: local, because the limits of its action will be found at intervals along that edge of the disc, near which the beam of light passes: specific, because scarce any other light seems to be decidedly subject to it except such as proceeds from the sun's disc or its immediate neighbourhood, and from certain stars.

He then proceeds to show how the laws thus qualified explain and reconcile many of the observed phenomena.

I. If a minute beam from a star, which is about to be occulted, pass near to that region of the moon's limb at which the distortion outward may prevail, the rays of light will be more and more bent

Fig. 1.

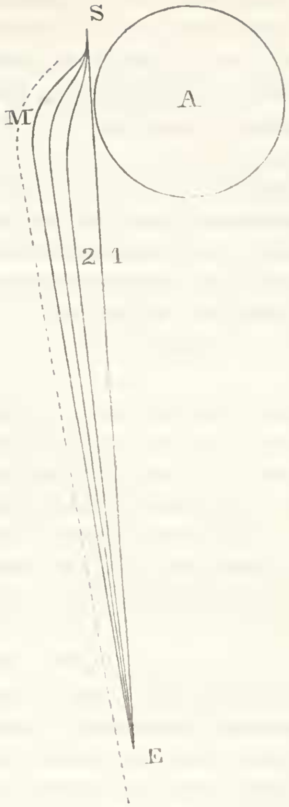
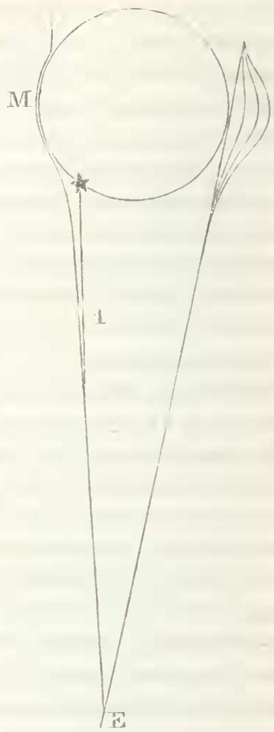


Fig. 2.



as in fig. 1, until the flexure arrives at its maximum, the moon's edge having advanced to M, or very near it. During this interval, the spectator at E will see the star in the successive directions of the straight portions of the lines E 1, E 2, &c.; i. e. he will continually see the star very near the moon's edge, or—if it have a small spurious disc—in apparent contact with the edge, and seeming therefore to adhere to the limb. As the moon advances still further, the ray which passes by M will be cut off; the next distorted beam, being bent in a direction sensibly parallel to the last, as represented by the dotted line in the figure, can no longer reach E; so that the edge of the moon having arrived at or near to M, the star will suddenly disappear. Thus is explained phenomenon 4 of *Tab. II.* The same species of action will also account for the similar appearances which occur in an inverse order, at the emersion whether of sun or star; including thus the principal phenomena described in *Tab. I.* 29.

II. If the minute beam from the star which is about to be occulted pass near to that region of the moon at which the distortion inward may prevail, then will the rays of light which the moon approaches be successively more and more bent, until the edge of the moon arrive at or near to M in fig. 2, when the star will be seen by the spectator at E in the direction E 1, and it will appear as in the figure, projected on the moon's surface; the rays which reach his eye from the intervening portions of the disc being either not thus affected, or in a far inferior degree. This projection must for like reasons commence before the edge reaches the limit at M; and as the rays are continually more and more curved, the star will continue to advance upon the disc, until the ray which passes by M will be cut off: the next distorted beam, as in the other case, cannot reach the eye; and the star will suddenly disappear, seeming to leap out of sight. Thus the phenomenon described *Tab. II.* 1, is accounted for in its origin, progress, and termination; including also the rapid motion at the immersion, described *Tab. II.* 8.

III. At the formation of the annulus, the sun's limb which is about to appear, and the luminous envelope of Bessel which closely surrounds it, will each be in a measure analogous to a continuous curve of stars in seemingly close contact, and just about to emerge from the moon's limb. Now the tendency of the distortion inward, wherever it might prevail, would be in the first instance to project upon the moon the several stars exposed to its influence; while the tendency of the distortion outward would be to keep the stars exposed to its influence in close contact with the edge of the disc; and both would most probably be efficient for about the same length of time.*

It might be presumed, therefore, if both species of action should exist at intervals along the visibly continuous arch of the sun's limb, or its luminous envelope, that several isolated spots of light would be seen indenting the edge of the moon's limb, if not actually projected on it; while at other places along the edge of the disc, portions of the luminous arch would scarcely be seen at all, being kept in close contact with the edge by the other species of distortion. As, however, the light of the luminous envelope has been observed to diminish in intensity in a direction from the sun, it might be that the light sub-

* This is ascertained by a comparison of the mean durations of the projection and adhesion of stars, phenomena 1 and 4 of Tab. II.

ject to the action of the distortion inward, would not all be affected to the same extent, and thus no isolated spot be seen projected on the disc, though the limb must still be indented. The appearance arising from both actions combined would therefore resemble that of a row of drops, connected by slender filaments. But should the distortion inward precede the other a very little, the indentations would first be seen alone, and present the appearance of a row of drops with intervening dark spaces. As the moon afterwards advanced, the drops, in accordance with Law II. would begin to pass off; while the light, having slightly emerged at the intervening spots along the edge, would continue to adhere in the form of slender threads, or broader bands, connecting the drops. At a later period the drops would pass off, the intervening threads would be released from their adhesion, and the whole would run together, completing a comparatively smooth ring, whose breadth might at first be less than that of the drops.

The same, in an inverse order, might take place at the dissolution of the annulus, which implies the immersion of a luminous arch. The emersion of a small portion of the sun from a total eclipse, would moreover be analogous to the formation of the annulus, and might present like phenomena; while the immersion of the last narrow and shortened portion of the sun, at the beginning of the total obscuration, might exhibit appearances similar to those seen at the dissolution of the annulus.

All the phenomena described in the first part of *Tab. I.* 14, are thus accounted for in their commencement, progress, and termination.

The exposition thus far, does not include the dark lines observed by Prof. Van Swinden in 1820, nor those, and the phenomena preceding them, which were seen in such rare perfection by Mr. Baily and others, in 1836.

Should however the distortion inward be very feeble, or scarcely exist at all, the indentations would at first be very small, and the portions of the luminous arch at which such distortion took place, might almost immediately pass off the disc; but the distortion outward being still efficient, the adhesion would still continue, and might either commence later or continue longer at some places than others. The bright spots must therefore appear wider and deeper, and the dark spots narrower and longer, until, the effect having reached its limit, the dark lines would break off. All this time, the ends of the dark lines towards the moon's limb would most probably be separated from it by fine filaments of light, though the minuteness of these as well as the rapidity of the other changes might prevent their being observed.

The same appearances might recur in an inverse order, at the dissolution of the annulus, and thus present phenomena similar to those observed by Mr. Baily, in their origin, progress, and termination. The hypothesis explains in this manner all the phenomena of *Tab. I.* 14.

The prescribed limits of this abstract exclude the detailed applications of Prof. A.'s law to the numerous other phenomena which it reconciles. In general, it may be said, that among these phenomena are, the elongation, shortening, and flexure of cusps, *Tab. I.* 4, *and III.* 1,—the apparent gliding of a star on the edge of the disc before immersion, *Tab. II.* 5,—the distortion of the moon's disc, *Tab. I.* 16,—the division of the planet's disc, *Tab. II.* 3,—the prominent dark points on the sun's disc at the commencement of an eclipse, *Tab. I.* 2 *and* 29,—the dark lines on the sun's limb, near the beginning or ending of the eclipse, *Tab. I.* 3,—the illuminated solar spot, *Tab. I.* 8,—the sudden formation of the annulus, *Tab. I.* 17,—the brilliant spot on the moon's disc after the total immersion of the sun, *Tab. I.* 25.

Prof. A. remarks, in continuation, that the hypothesis of the distorting action of the moon is confirmed also by the fact, that the mean duration of the drops and dark lines in eclipses, so far as ascertained, is nearly identical with that of the projections and adhesions of stars in occultations;—the duration of the drops having been in 1806, $4^s.5$ —their mean duration in 1820, $2^s.44$, and in 1836, $9^s.0$,—and their duration in 1838 at the beginning and end, $6^s.33$, and at the annular eclipse, $4^s.7$; giving a general mean of $5^s.2$: while the mean duration of the changes at occultations is $4^s.5$,—or when two unusual instances of nearly 15^s. each are included, $5^s.0$. Further confirmation of it is found in the analogy presented by phenomena seen during transits, *Tab. IV.* 1, 3, 4, 6,—13, *and* 19—24 *inclusive*, and *Tab. V.* 1, 2, 7, 9:—and that this analogy is real, is sustained by the appearances of Venus and Mercury, noticed in *Tab. VI.* 3—11, and *Tab. VII.* 1, 3, 4.

Traces of the local action of the moon upon light have been observed also on other occasions; *Tab. III.* 4, 5:—and effects similar to some of these distortions have been produced by artificially eclipsing the sun and stars.

Another analogy in the action of the moon and Venus upon light is presented in the tremulous motion near the moon's limb in eclipses, and the similar appearance near the limb of Venus in transits;—and that this last is due to the action of the planet appears by reference to *Tab. IV.* 1, 2, 3, 9—12, and to the fact, that the phenomena there described interfered with and quieted the unsteadiness of the sun's limb, produced by irregular refraction. The phenomena noticed in *Tab. I.* 5, may therefore be referred to the action of some unexplained cause in the moon. The flashes, described *Tab. I.* 6, seem to be dependent upon the action of some cause in the moon, since they usually come from the moon's edge; and the same may be said of the spots and traces of light, mentioned in *Tab. I.* 9.

Prof. A. next considers the *corona*, *Tab. I.* 20, and examines in succession the hypotheses to which it has given rise. After discussing those which refer it to the action of the earth's atmosphere, and to the diffractive influence of the moon, and giving the arguments at large in favour of a lunar atmosphere, he rejects all these, as either contrary to known facts, or inadequate to explain the phenomenon; and passes to the inquiry, whether it may not be due to the same widely diffused luminous substance, which is also apparent in the zodiacal light. He presents in detail the considerations on both sides of this question; and concludes, that notwithstanding the measurement made by the associates of M. Arago at Perpignan in 1842, which led them to the conclusion that the corona was concentric with the moon, there is yet reason to accept this hypothesis, as the one most generally accordant with all the facts that have been observed.

He then suggests distinct explanations for the several other phenomena mentioned in his tables; referring some of them to atmospheric action, some to earth-light, others to the effects of contrast, others again to a glare of light within the telescope, &c. &c., and closes his elaborate paper by some conjectures as to the cause of the distinct outline exhibited by the ribbon of light, 26 *of Tab. I.*, in 1806 and 1834; as well as that of the distortion, of which he has endeavoured to trace the laws and mode of action.

The great heat of the sun's surface, he says, would seem to render it possible that a comparative vacuum may be maintained there; or in other words, that the density of his envelope may be almost incomparably less at his surface than at a very short distance from it. A somewhat abrupt change of density will thus be effected; and the light which arrives at the limit of this vacuum will be copiously reflected, upon the principle that light is always thus reflected at the common surface of media differing in density. This light will pass through the nebulosity on all sides, as the sun's rays shine through a comet; and the limit of the vacuum being seen very obliquely or foreshortened near the edges, it must present something like a distinct boundary.

Again; he proceeds, whatever may be said of the reason assigned by Dr. Halley for the dim light of the sun before his immersion; namely, the vapours in the moon's atmosphere, collected during the long night; yet it would seem to be very certain, that the temperature of the western edge, which is just then passing from night to day, must be decidedly lower than that of the eastern edge, which has been exposed to the sun's light for many days together. The same will, vice versa, be true with regard to the other edge in its turn.*

The distribution of temperature would, on other accounts also, be very unequal over that part of the surface,—somewhat more than a hemisphere,—which alone is ever visible to us. For the great annular pits would tend to concentrate the heat reflected from their surfaces; and should there be any thing vapourable near their centres, it must feel the effect of this concentrated and long continued heat. A distribution of unequally heated spots would thus be produced; which spots, moreover, would again in all probability be unequally cooled during the long night. The local action upon light, as it passed near these heated pits, might therefore be in some respects the negative of that exerted by the colder portions, and none would probably be colder than those mountains which have not the crater-like form.

In these disposing causes, he says, may perhaps be found the origin of the two species of distortion which have been described in this paper. If, moreover, the distortion inward belong to the pits, and the distortion outward to the eminences; then, at the formation of the annulus, the former would a little precede the latter,—a supposition which, as has been seen, explains the phenomena in some cases more fully.

Apart from any such speculations, however, the following, he remarks, is a summary of the conclusions to which the preceding investigation appears to lead:—

* See Sir John Herschell's Treatise on Astronomy, page 219

1. That if the moon were surrounded by an atmospheric envelope, such envelope must be affected by a terrestrial and anti-terrestrial tide, the great waves of which must uniformly be accumulated nearly above the centre of the disc, and the point diametrically opposite, thus leaving the edges comparatively destitute.

2. That among the causes of the physical phenomena attending solar eclipses and occultations;—besides atmospheric action, earth-light, and others;—must be specially recognised a distorting action, of a two-fold character, exerted upon light by the moon:—that this action is—1. local; 2. specific; and that it seems to be exerted either upon the light at the sun's limb, or upon a luminous substance or substances surrounding the sun:—and

3. That to this luminous substance is due the corona.

Prof. A. adds some supplementary remarks, in the course of which he quotes several other observations, as furnishing additional proof of the existence of specific peculiarities in envelopes of the various planets of the solar system. These, he says, seem to afford ground for a somewhat broad generalization, viz:—*that an atmosphere properly so called is probably peculiar to the earth.*

Professor Bache, from the sub-committee of arrangements, announced that the programme of the meeting had now been gone through.

In the absence of the President from indisposition, Dr. Chapman, one of the Vice-Presidents, then made some parting remarks on the manner in which the hundredth anniversary of the Society had been celebrated. He adverted to the dignified and imposing assemblage which had done honour to the anniversary ceremonies, the high scientific character of the gentlemen who had taken part in the special meeting which was now about to close, the ability and enlarged scope of the communications presented before it, and the intelligent interest manifested in all its proceedings by the numerous strangers and citizens who had witnessed them.

Dr. C. then spoke of the agreeable recollections which would remain after this celebration, the incitement it had given to fresh scientific labour, the sympathies it had awakened and revived among men engaged in various though kindred pursuits. and the personal friendships it had so happily established. He tendered the thanks of the Society to all who had honoured it by their presence on the occasion; and bidding them a respectful farewell, expressed an earnest wish that the recurrence of so grateful a communion of mind might not be long postponed.

Note to Mr. Tyson's Paper, Page 124.

In a note to the Reporter, Mr. Tyson refers to an original document in the possession of Mr. George M. Justice, of Philadelphia, and recently communicated by him to the Historical Society of Pennsylvania, as correcting the statement, which Mr. Bancroft and others have admitted, that William Penn was at one time a slaveholder.